COMPARING MICRO-PEMS AND 1065 COMPLIANT PEMS RESULTS FROM FIELD TESTS OF AN ALL-TERRAIN VEHICLE

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Outline of Presentation

- The Need:
  - Requirements to in-use test smaller vehicles making legacy PEMS impractically large and heavy.
  - Can mini-PEMS and flow modeling algorithms produce results of adequate quality?
- Data Collection and Results
- Conclusions and Discussion
- Q & A

The Trend – and Issue

- Regulatory requirements for in-use testing are extending to smaller and smaller vehicle platforms
- For example, (EU) 2016/1628 (the Stage V emission regulation):
  - covers previously unregulated engines, including snowmobiles, All Terrain Vehicles (ATV) and engines below 19 kW.
  - requires (for the first time) the collection of in-use emissions from in-service engines in non-road mobile machinery during “normal” operation.

Normal Operation?

Gioria, R., Perujo Mateos Del Parque, A., Carriero, M., Forni, F., Montigny, F. and Padovan, V., Non Road All Terrain Vehicle & Side-by-Side In Service Monitoring based on PEMS, EUR 29920 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-12561-7, doi:10.2760/542636, JRC117967.

Typical Vehicles

Project

- Investigate practicality of using micro-PEMS for regulatory testing
  - "Piggyback" onto existing in-use PEMS tests of large ATV
  - Measure using micro-PEMS simultaneously
  - Use results to recommend feasible path to representative testing of smaller ATV

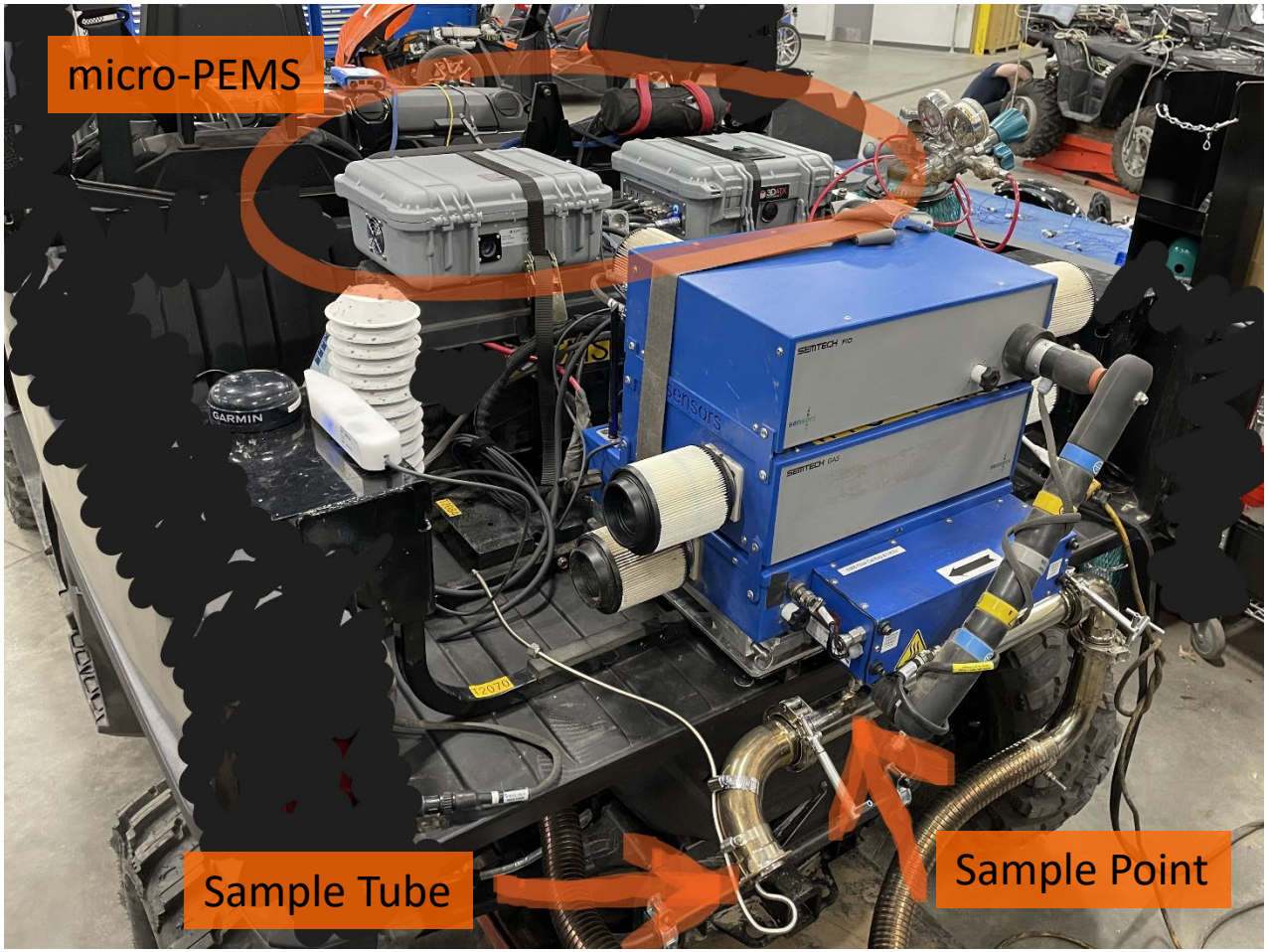
Location & Duty Cycles

- Off-roading facility near Polaris HQ in Minnesota.
- Drive large ATV in four “typical” ways
  - Hunter
  - Utility/Work Site
  - Rancher
    - Highest payload/towing
  - Recreation/Camping
    - Most aggressive and similar to how smaller ATVs are used.

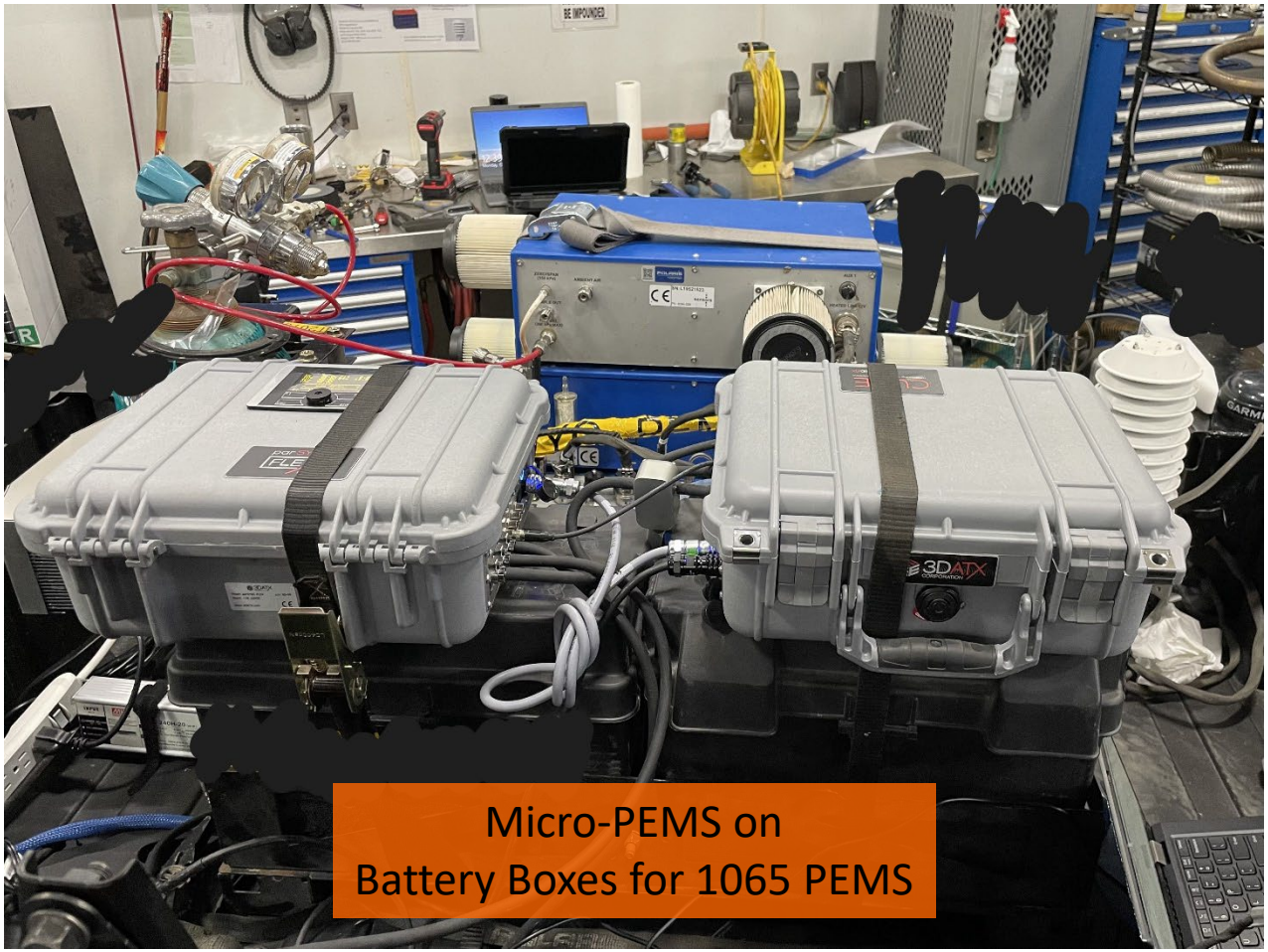
Test Vehicle

- Not yet introduced large ATV
  - Pre-production unit
  - Non-final powertrain calibrations
- Similar in size to…

Instrumentation



Micro-PEMS

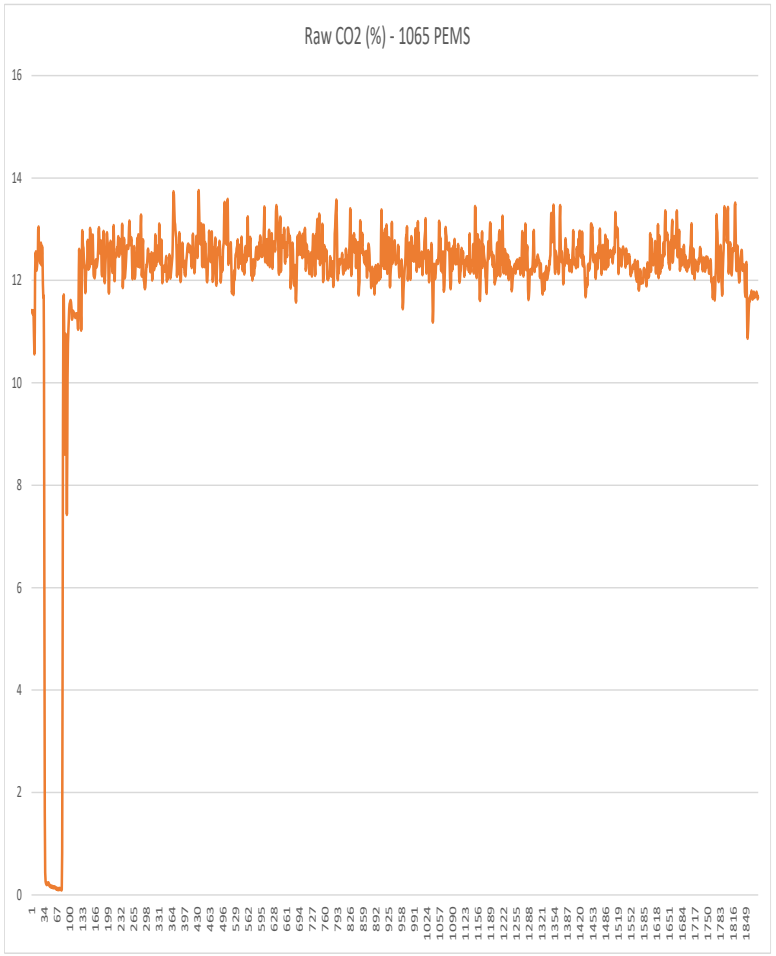


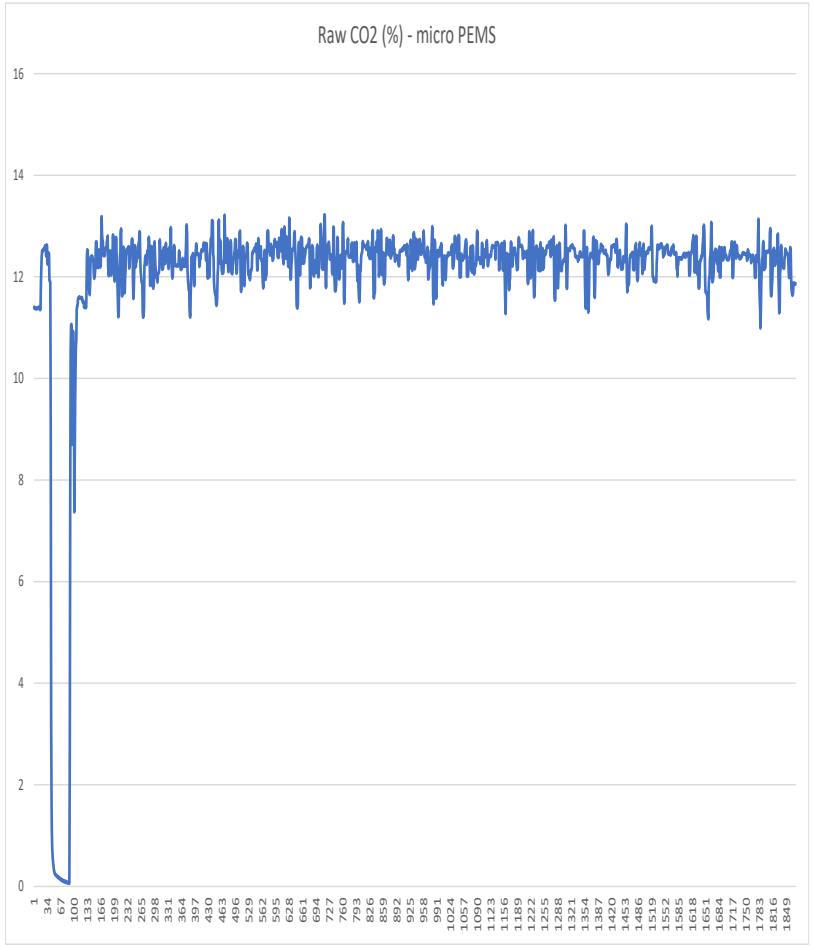
Micro-PEMS on
Battery Boxes for 1065 PEMS

The Test

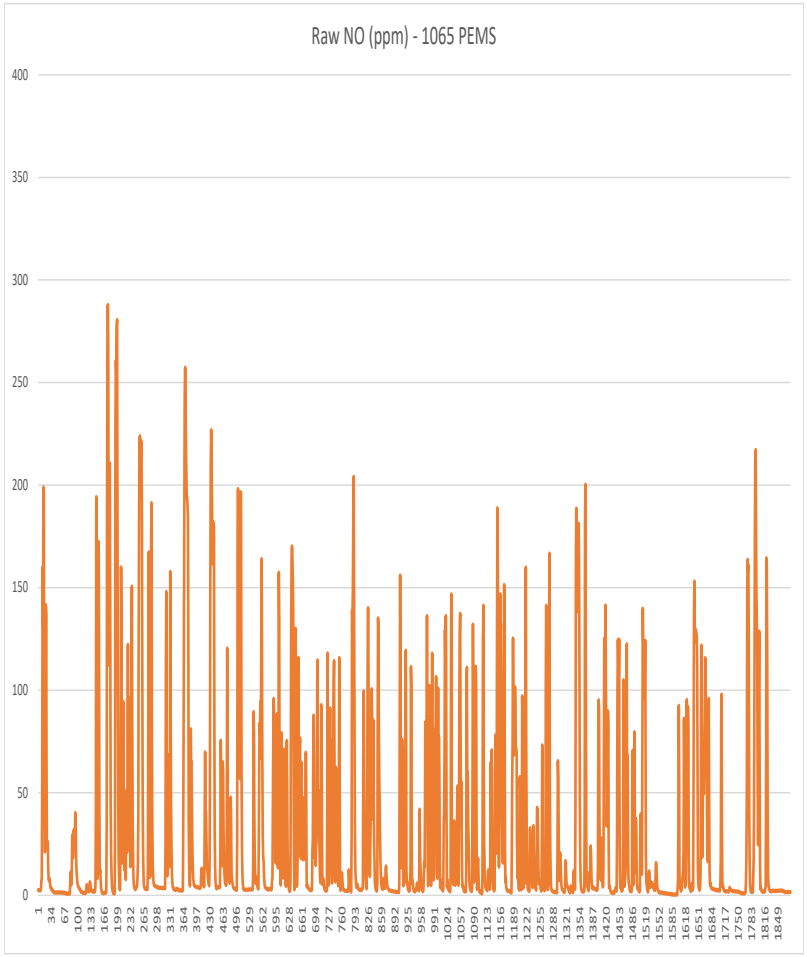
- Drive the “Recreational” route and duty-cycle
- Measure exhaust concentrations in parallel
- Measure exhaust flow rate using PEMS “Bernoulli based” flow meter
- Estimate exhaust flow rate using engine control module algorithm

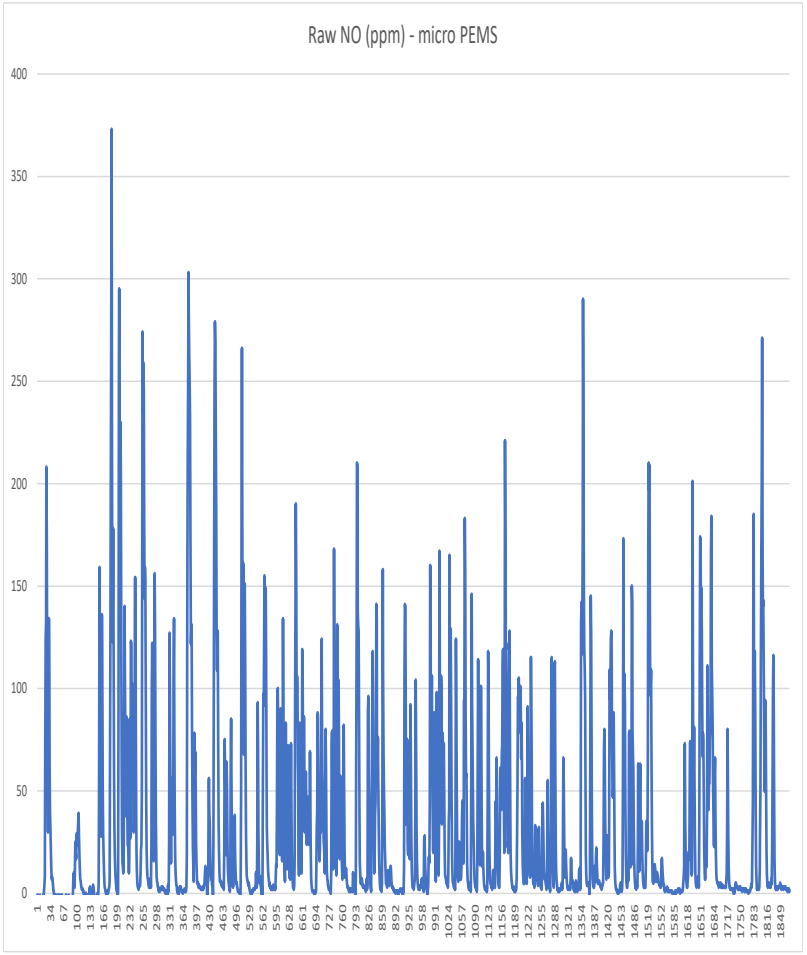
Carbon Dioxide



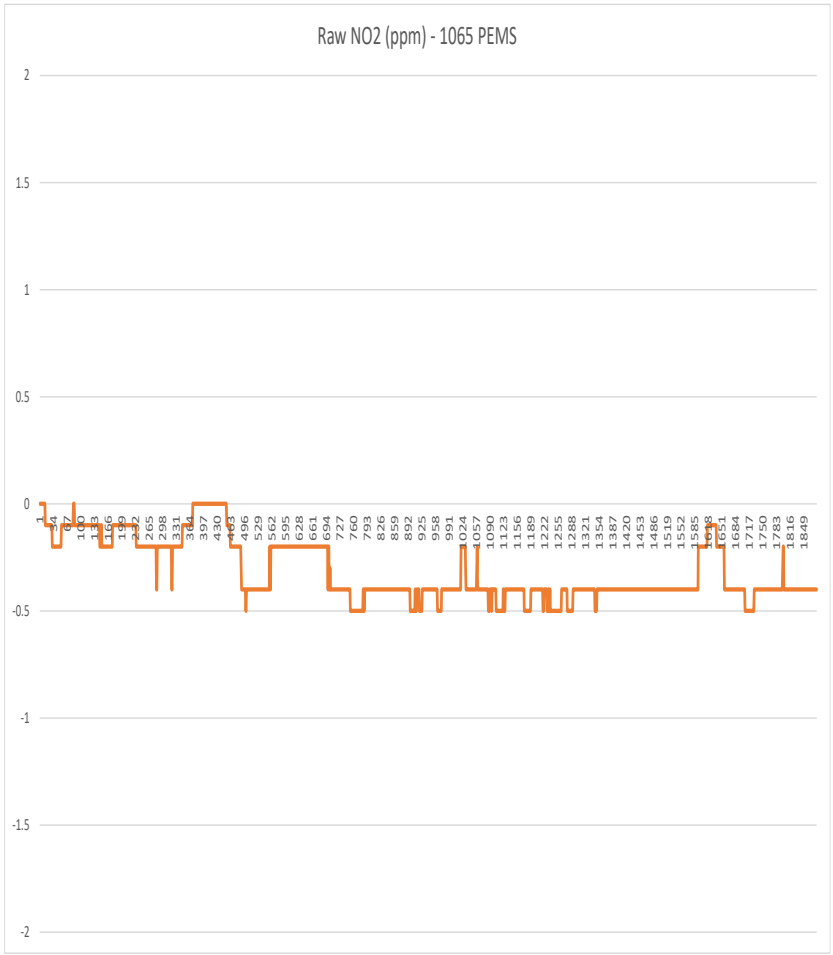


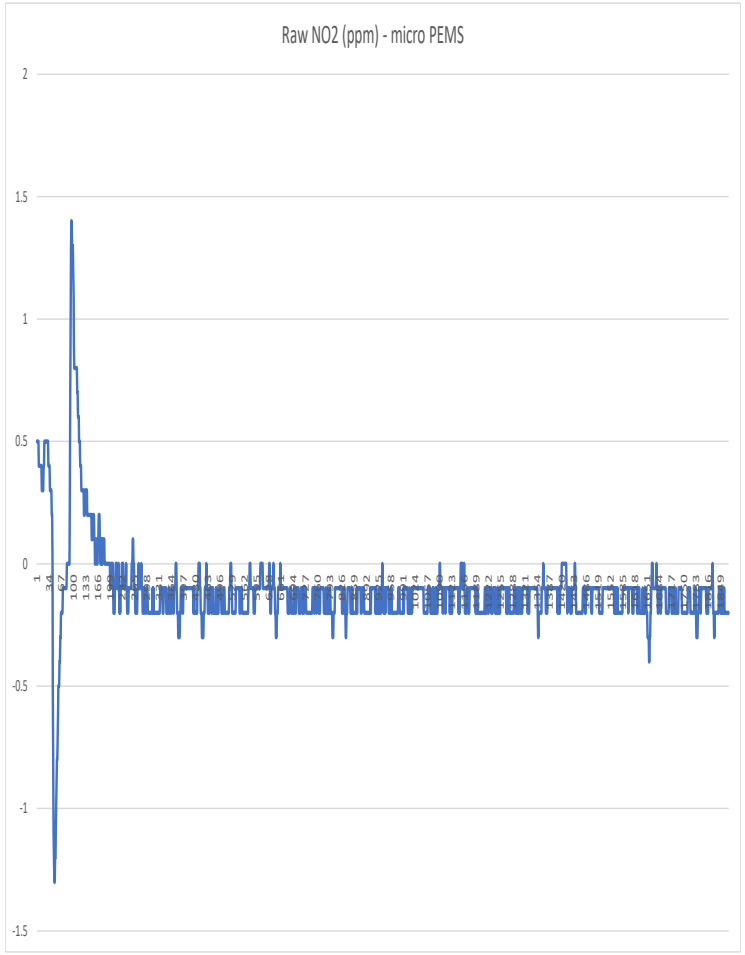
Nitrogen Dioxide





Nitrogen Oxide

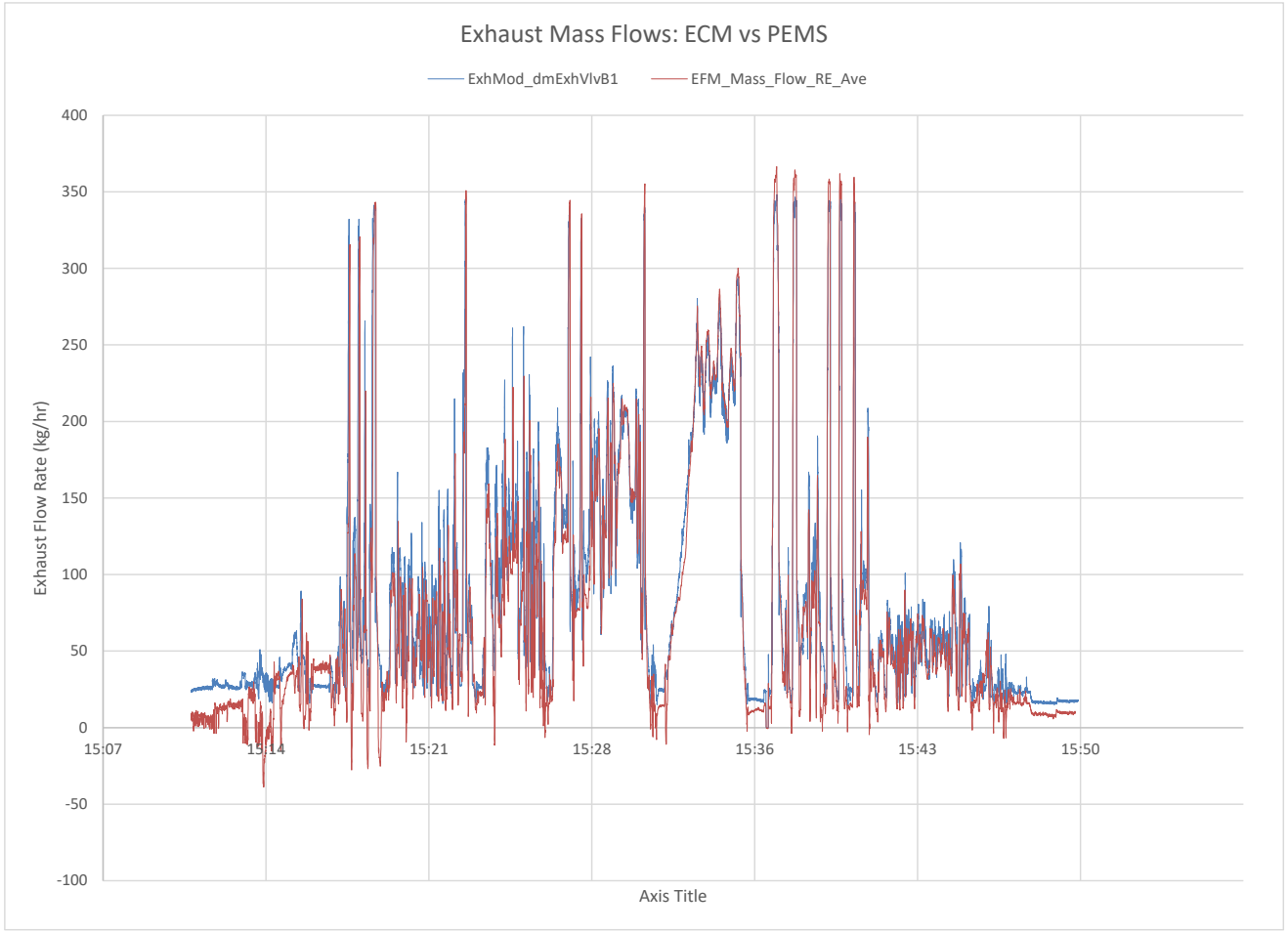




Total Hydrocarbons

- Ooops. No THC yet. But soon.
- See, for example…

Flows:
ECM vs Bernoulli Differential Pressure



Flow Measurement Problem: Small Engine at Low Flow

- Pressure Pulsations and flow reversion cause errors
  - Bi-directional, high-speed sampling can mitigate this somewhat.
  - Pulsation damping can help too.
  - But single-cylinder, low flow is a problem for Bernoulli based flow measurement.

- See, for example:

Ensfield et al., ENGINE EXHAUST FLOW MEASUREMENT WITH PULSATION COMPENSATION, United States Patent US 10,823,593 B2, Nov. 3 , 2020.

Refined Flow Modeling by ECM

- Collect comparative data on the dynamometer.
  - Pre-defined steady-state and transient operational modes to cover expected range.
  - Parallel collection of exhaust flow and ECM inputs.
  - Higher data collection at low flows.
  - Refine the modeled ECM algorithm to match empirical data.
  - Make the output “public” in the OBD data stream.

Q? ➔ A!

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